Investigating the Sources and Optical Importance of Brown Carbon during DC3 and SEAC4RS

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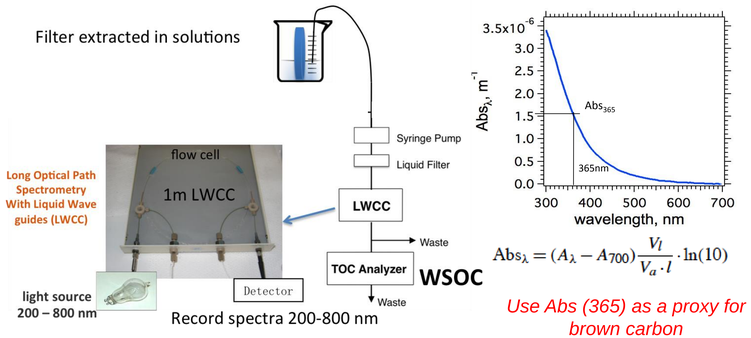
Objectives

- DC3: Assess Optical Importance of BrC in Background Continental Troposphere.
- SEAC4RS: Investigate BrC in biomass burning plumes:
  - Comparison of direct measured BrC to Ångström Exponents from optical instruments (PSAP and possibly PAS)
  - Prevalence of BrC relative to BC
  - Formation of BrC with plume aging (secondary BrC) ?
  - BrC versus Mixing State (Shell Cores) and light absorption

Method: Direct Measurement of BrC

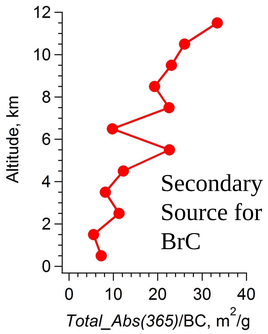


$$Abs_\lambda = (A_\lambda - A_{700})\frac{Vl}{V_a \cdot l}\cdot \ln(10)$$

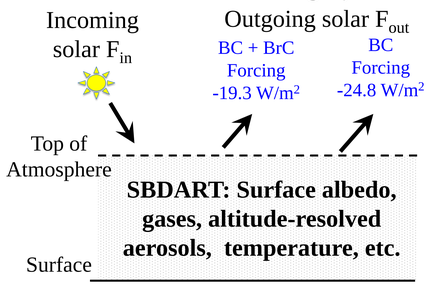
- ***Brown carbon determined from solution extracts***
- *Isolate brown carbon from other light absorbers*
- *Highly wavelength-resolved*

DC3 Results Summary: No Plumes

BrC/BC Increases with Altitude



Direct Radiative Forcing by BrC

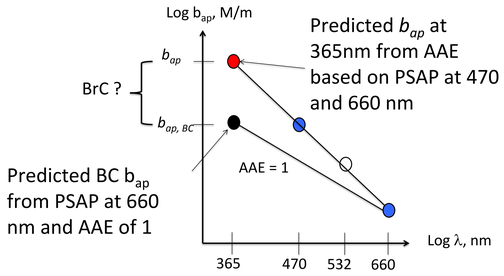


BrC ~20% of TOA absorbing aerosol direct radiative forcing

See: *Liu et al, Geophys. Res. Lett., 41, doi:10.1002/2013GL058976*

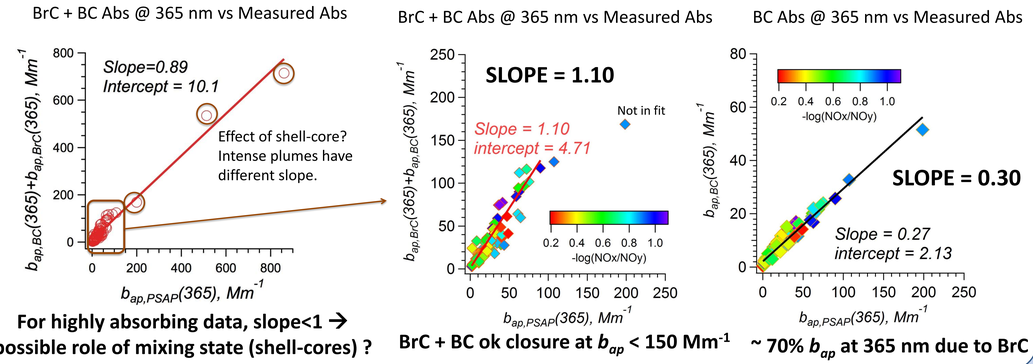
SEAC4RS RESULTS

Use of 3-λ PSAP Data



Use of PSAP data averaged to filter sampling times to determine: AAE, b_{ap} at 365 nm of BC, Total b_{ap}

Optical Closure: BrC & BC @ 365nm



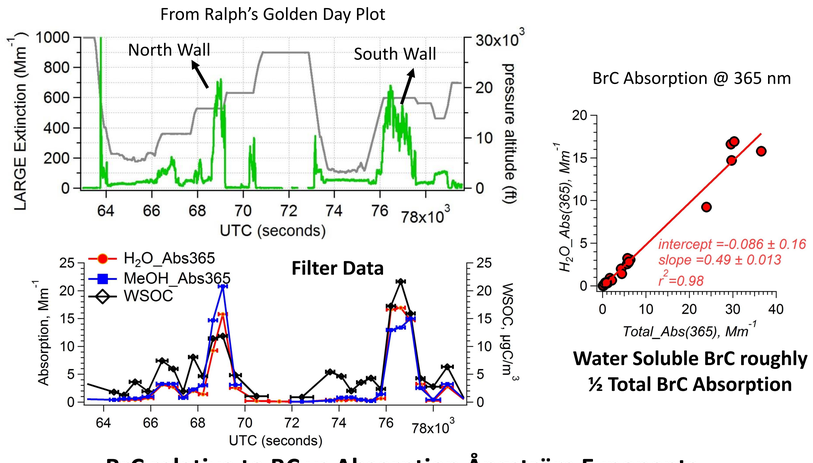
For highly absorbing data, slope<1 → possible role of mixing state (shell-cores) ?

BrC + BC ok closure at b_{ap} < 150 Mm^{-1}

~ 70% b_{ap} at 365 nm due to BrC

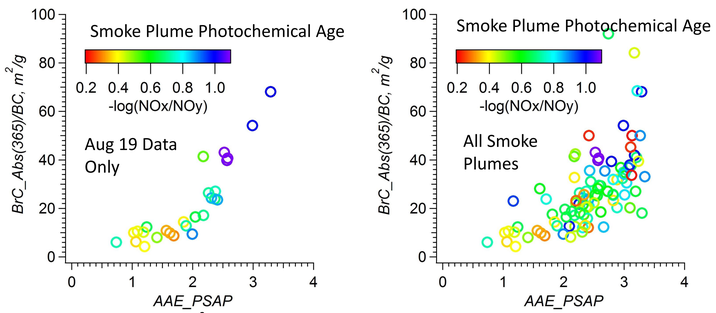
Note on comparison between PAS (photo-acoustic instrument) and PSAP. Absorption coefficients are highly correlated (r > 0.95) and averaging over the PAS sampling period $\boldsymbol{AAE_{PAS}/AAE_{PSAP} = 0.90}$

Aug. 19 Flight: BrC and AAE



Water Soluble BrC roughly ½ Total BrC Absorption

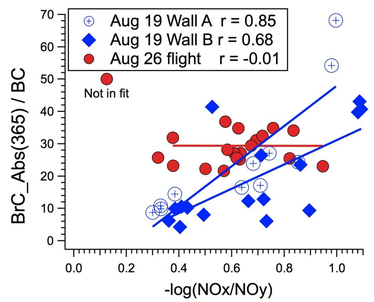
BrC relative to BC vs Absorption Ångström Exponents



At PSAP Absorption Ångström Exponents greater than ~1 to 1.5, BrC Absorption wrt BC concentration increases with AAEs. Pure BC AAE ~ 1.

AAEs > 1 are linked to BrC

Is BrC Formed as Smoke Plume Ages ?



Possible evidence in some plumes that BrC may form as plume ages

Plume	Evidence for BrC/BC increase with plume age
Aug 06	maybe
Aug 19	yes
Aug 26	No
Aug 27	yes
Sep 06	1 data pt
Sep 09	No BC data
Sep 11	2 data pts
Sep 16	No (negative slope)
Sep 23	maybe

Summary/Future Work

1. BrC is a significant light absorbing component of biomass burning plumes
   - Good closure between light absorption from BrC and observed abs at 365 nm
   - ~70% of light absorption at 365 nm from BrC (lower % at higher wavelengths)
   - ~ ½ of BrC is water-soluble (Aug. 19 plumes).
2. Possible evidence of shell-core effects on light absorption at high loadings?
3. Secondary BrC production may occur in select plumes.
   - Will compare with evolution of other plume parameters to assess why.
4. Future Work: Assess contribution of BrC in smoke plumes to:
   - Atmospheric stability (T profile), cloud microphysics, regional Climate via CMAQ